



SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES

NALAIYATHIRAN PROJECT BASED LEARNING

On

PROFESSIONAL READINESS FOR INNOVATION, EMPLOYABILITY, AND ENTREPRENEURSHIP

A PROJECT REPORT TEAM ID : PNT2022TMID47019

TEAM MEMBERS :

SELCIA M	-	822119106021
MURALIDARAN R	-	822119106014
SNEHASRI N	-	822119106023
VINOTHA C	-	822119106029

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UNIVERSITY COLLEGE OF ENGINEERING -PATTUKKOTTAI

(A Constituent College of Anna University, Chennai)

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Abstract:

Our waste generation is constantly growing to form a global garbage crisis. Even though we indulge in creating a more sustainable and greener, we still fail to handle our waste generation and management. Combining technology support with a vision of social, economic and environmental sustainability is the best way out of this problem. It is done in the following manner. The smart bin system undergoes a thorough system check and battery level monitoring in order to function efficiently. If the battery level is found to be low, it has to be recharged immediately, else it can proceed to the next step. The threshold level levels of the bin are indicated by multiple sensors attached to bin. If the garbage exceeds the level, then an alert message is sent to the garbage collectors as well as to the municipality or area administration. The area in which garbage is found to overflow is allocated to respective garbage collectors in the form of messages through GSM system. Once the waste bin is emptied, an information update is sent to the municipality and server is updated. This is how the waste from bins can be efficiently handled and managed using technology which in turn keeps the environment clean and healthy.

Purpose:

We amalgamate technology along with waste management in order to effectively create a safe and a hygienic environment. Smart waste management is about using technology and data to create a more efficient waste industry. Based on IoT (Internet of Things) technology, smart waste management aims to optimize resource allocation, reduce running costs, and increase the sustainability of waste services. This makes it possible to plan more efficient routes for the trash collectors who empty the bins, but also lowers the chance of any bin being full for over a week. A good level of coordination exists between the garbage collectors and the information supplied via technology. This makes them well aware of the existing garbage level and instigate them whenever the bins reach the threshold level. They are sent with alert messages so that they can collect the garbage on time without littering the surrounding area. The fill patterns of specific containers can be identified by historical data and managed accordingly in the long term. In addition to hardware solutions, mobile applications are used to overcome the challenges in the regular waste management system, such as keeping track of the drivers while they are operating on the field. Thus, smart waste management provides us with the most optimal way of managing the waste in an efficient manner using technology

Waste management has become an alarming challenge in local towns and cities across the world. Often the local area bins are overflowing and the municipalities are not aware of it. This affects the residents of that particular area in numerous ways starting from bad odour to unhygienic and unsafe surroundings. Poor waste management - ranging from non-existing collection systems to ineffective disposal - causes air pollution, water and soil contamination. Open and unsanitary areas contribute to contamination of drinking water and can cause infection and transmit diseases. Toxic components such as Persistent Organic Pollutants

(POPs) pose particularly significant risks to human health and the environment as they accumulate through the food chain. Animals eating contaminated plants have higher doses of contaminants than if they were directly exposed. Precipitation or surface water seeping through waste will absorb hazardous components from landfills, agricultural areas, feedlots, etc. and carry them into surface and groundwater. Contaminated groundwater also poses a great health risk, as it is often used for drinking, bathing and recreation, as well as in agricultural and industrial activities. Landfills and waste transfer stations can attract various pests (insects, rodents, gulls, etc.) that look for food from waste. These pests can spread diseases through viruses and bacteria (i.e., salmonella and e-coli), which are a risk to human health

Skills Required:

Python, IOT Cloud Platform, IBM Cloud, Node-RED, IBM IoT Platform, IBM Node-RED, IBM Cloudant DB

CHAPTER-1

INTRODUCTION

Internet and its applications have become an integral part of today's human lifestyle. It has become an essential tool in every aspect. The world is in a process of updation, and there is one stinking problem we have to deal with. Garbage! In our daily life, we see the pictures of garbage bins being overfull and all the garbage spills out. This leads to the number of diseases and insects and mosquitoes breed on it. A big challenge in the cities is solid waste management not only in India but for most of the countries in the world. Hence, such a system has to be build which can eradicate this problem which reduces the minimum level. The waste collection process is a critical aspect for the service providers. In order to overcome all these problems, we are proposing the idea of a waste management system in metropolitan cities which helps in the management of waste with the least human interaction in order to maintain a clean environment. IoT Garbage Monitoring System monitors the garbage bins and informs about the level of garbage collected in the garbage bins via LED. We are making use of various sensors to scan type of garbage and then categorize them to different bins by automatically opening the door. It also uses ultrasonic sensors placed over the bins to detect the garbage level. It will stop overflowing of dustbins along roadsides and localities as smart bins are managed at real time. The filling and cleaning time of smart bin will also be reduced thus making empty and clean dustbins available to the people when its needed.

1.1 PROJECT OVERVIEW:

In developing countries like India where a rapid increase in population has been observed in past decades , solid waste management has become a critical issue. This issue arises mainly due to the improper segregation of waste. Waste management and dumping of solid wastes in India have been researched and findings show that municipal solid wastes are mostly composed of biodegradable and non biodegradable materials .Organic and Inorganic waste are treated in the same way and are not collected on time . This leads to loss of potential energy generated using organic wastes. The main problem of the existing solid waste process is the lack of information about collecting time and source available, also there will be lack of productivity due to inefficient utilization and unauthorized use of vehicles. As of now to overcome this disadvantage , household garbage can be converted into biogas and can be utilized for cooking purposes in home as well as it can be collected and thrown in the trash bin

instead of making the environment unhygiene. This will reduce amount of waste generated by each families which helps in planned and organized waste management solution . This step will serve as a huge step in formation of smart cities.

PURPOSE:

- The main purpose of smart waste management is
- To keep the area clean
- To avoid damage to human beings
- To collect the waste from the required area regularly

CHAPTER-2

LITREATURE SURVEY

S. No	Literature Surveyon Smart WasteManagement System				
	Title of the Paper	Authors	Algorithm	Advantages	Disadvantages
1	Cloud-based Smart Waste Management for SmartCities	Mohammad Aazam, MarcSt-Hilaire, Chung-HorngLung, Ioannis Lambadaris	Internet of Things (IoT),Cloud of Things,Cloud computing	Timely waste collection, Route optimization Recycling and disposal, Resource management, Waste-based energy production	System requires number of waste bins for separate waste collection
2	IOT Based Smart Garbage alert systemusi ng Arduino UNO	Sathish Kumar, Vuayalakshmi, Jenifer Prarthana, Shankar	RFID computing technology that is used for verification process and it also enhances the smart garbage alertsystem by providing automatic identification.	It is transportable low price RFID tag, the system provides options for the customers to lodge their complaints in caseof discrepance s.	Complex design of dustbin compared to other methods

3	Smartbin: Smart Waste Management System	Fachmin Folianto, Yong ShengLow, Wai Leong Yeow	Duty cycle technique to reduce power consumption and to maximize operational time. Applying sense-making methods to obtain litter bin utilization.	Obtain litterbin utilization - information showshow a bin has been utilized litter bin daily seasonality information.- shows the time when a bin is usually full	The sensor node was deployed with battery power. Low power consumption sensor node must be used because of its limited power. The sensor node had limited memory size.
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EXISTING PROBLEMS:

The main existing problem is that due to lack of dustbins there is a major cause to human beings. For example, if the waste is not collected on time by using the truck there will be major cause in that particular area where the waste will be dumped for days so that there will be an overflow from the dustbin and the area will be suffering from nasty smell. Because today's generation the people are not even trying to put waste in the particular dustbins allotted for their respected area. Also the existing system uses an LCD in each bins to indicate to the workers to notify them whether the bins has been filled.

REFERENCE:

1. A Survey on Garbage Collection and Monitoring system for Smart cities using IoT -Neha shinde, Varsha Devkule.
2. Waste Management Improvement in Cities using IoT - Ashwin Kumar Patil, Adithya Gandh.
3. Smart Waste Segregation and Monitoring system using IoT - - V.Sowndharya, P.Savitha, S.Hebziba Jeba Rani
4. IRJET-Smart City Waste Management System using IOT SERVER - Vaibhav.S Ballal , Sandhesh.S.Patil , Namdev.P.Dange
5. Arduino Microcontroller Based Smart Dustbins for Smart Cities - K. Suresh, S. Bhuvanesh and B. Krishna Devan

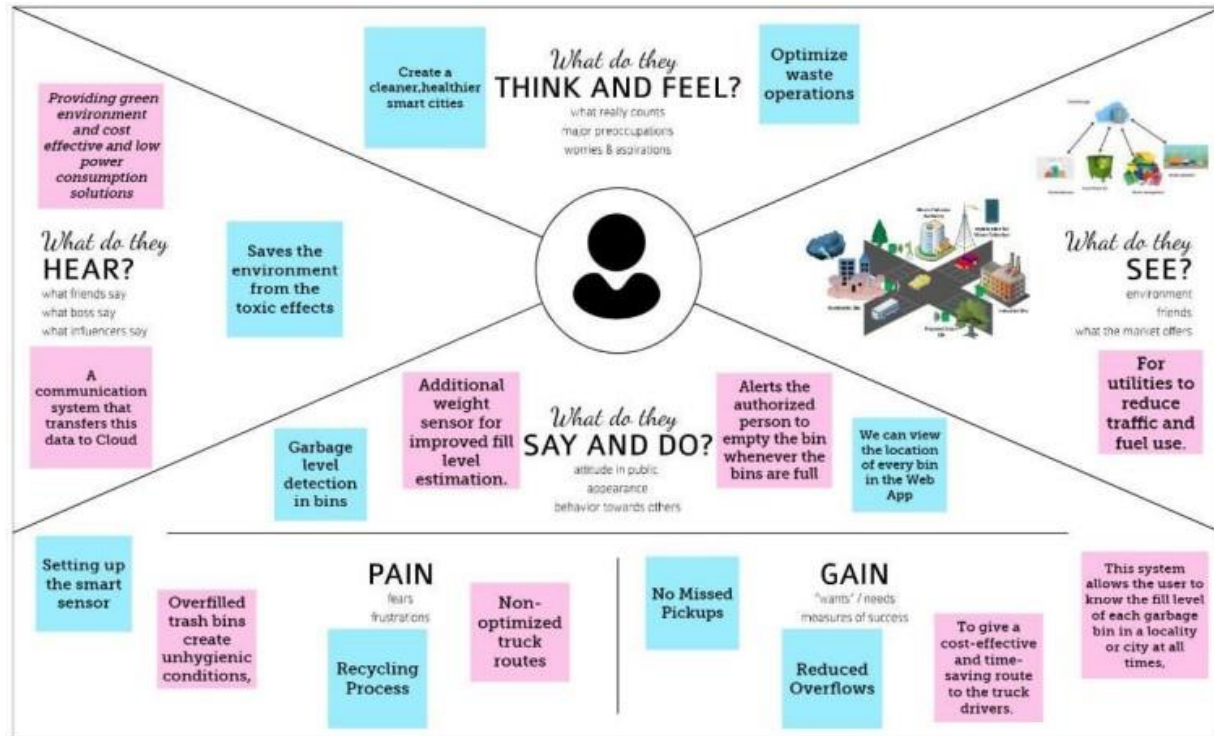
PROBLEM STATEMENT DEFINITION:

In developing countries like India where a rapid increase in population has been observed in past decades, solid waste management has become a critical issue. This issue arises mainly due to the improper segregation of waste. Waste management and dumping of solid wastes in India have been researched and findings show that municipal solid wastes are mostly composed of biodegradable and non-biodegradable materials. Organic and Inorganic waste are treated in the same way and are not collected on time. This leads to loss of potential energy generated using organic wastes. As of now to overcome this disadvantage, household garbage can be converted into biogas and can be utilized for cooking purposes in home as well as it can be collected and thrown in the trash bin instead of making the environment unhygiene. This will reduce amount of waste generated by each family which helps in planned and organized waste management solution. This step will serve as a huge step in formation of smart cities.

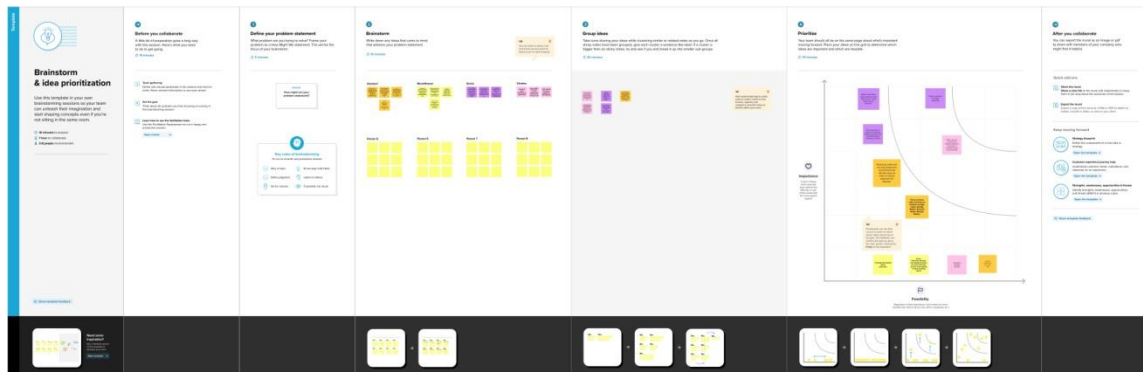
CHAPETR-3

IDEATION AND PROPOSED SOLUTION:

EMPATHY MAP:



Brain storm:



Proposed solution:

Project team shall fill the following information in proposed solution

SL .No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	<p>This proposed system deals with the problem of waste management in smart cities, where the garbage collection system is not optimized and in smart cities the efficient management of waste is a crucial challenge for the environment that IOT tends to address .</p> <p>This project enables the organizations to meet their needs of smart garbage management systems. This system allows the authorised person to alert the fill level of each garbage bin in a cities , to give a cost-effective and time-saving route to the truck drivers to collect the waste.</p>
2.	Idea / Solution description	<p>The key research objectives are as follows:</p> <ul style="list-style-type: none">• The proposed system would be able to do the waste bin includes a container with a lid, and its enclosure is equipped with sensors such as the HC-SR04 module, an ultrasonic sensor responsible for measuring the level of waste filling present inside the compartment. This is significant within the solution, because through its operation it is possible to avoid the overflow of waste or excessive garbage deposit. <p>*The Proposed system consists of main subsystems namely Smart Trash System(STS) and Smart Monitoring and Controlling Hut(SMCH).</p>

Problem Solution fit:

Define CS, fit into CC	1. CLIENT SECTION Smart waste management is an innovative approach to handling and collecting waste. Based on Internet of Things technology, smart waste management provides data on waste generation patterns and behaviour.	5. AVAILABLE SOLUTIONS Smart waste management is characterized by the usage of technology in order to be more efficient when it comes to managing waste. With the use of IoT solutions for waste management, these issues can be solved by creating more efficient pathway for garbage trucks.	8. CHANNELS OF BEHAVIOUR ONLINE: people may present/provide analysis and rating for this technology of smart waste management system. OFFLINE: People may provide a valuable resource and contribution to the organization	Explore AS, differentiate

Focus on J&P, tap into BE, understand RC	2. JOBS-TO-BE-DONE Smart waste management solutions provide real time insights on waste fill levels, collection routes, and bin movements and locations.	6. CUSTOMER PRESSURE There is no separation of bins are contribute. Waste management in cities is often times the most expensive item of investment as it involves both the collection of waste and its transportation for appropriate disposal. Over the last couple of years, technologies have been created for smart waste management to improve the collection and disposal of waste. Waste bins equipped with sensors now provide data on waste disposal, allowing cities to save resources and costs. These are seemingly effective ways to manage waste yet it challenges are still rife.	9. PROBLEM ROOT CAUSE There are some problems created when facing the waste/recycling industry. Misunderstanding of the operations of smart sensors, setting up the smart sensor, non-optimized track routes, recycling and non-uniform waste distribution of waste in bins.	Focus on J&P, tap into BE, understand RC

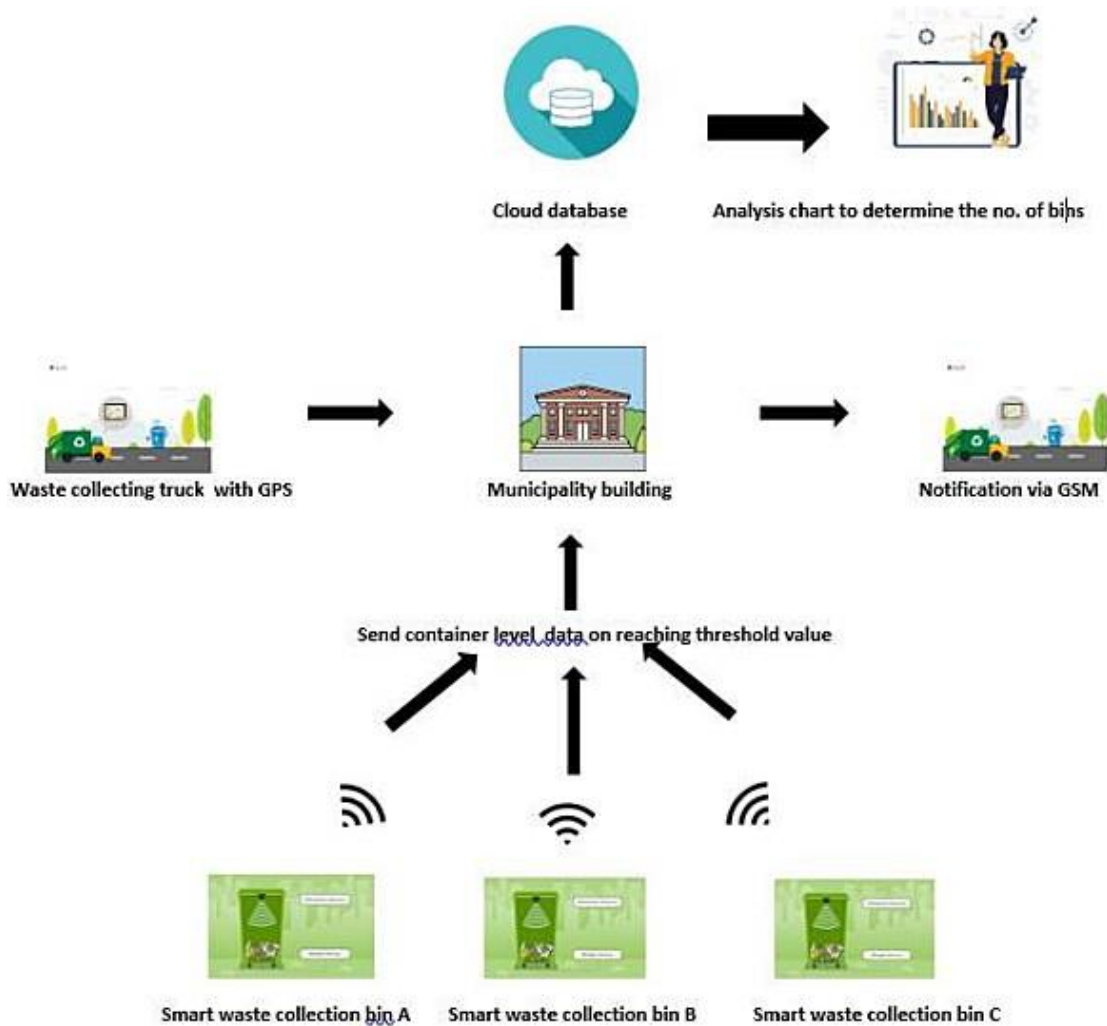
Identify strong TR & EM	3. ACTIVATE After initiating the project we can activate society by seeing their neighbour peoples produce the fulfillment of technology more useful and reading about a more efficient solution in the news.	7. BEHAVIOUR A reduction in the number of waste collections needed by up to 80%, resulting in less manpower, emissions, fuel use and traffic congestion. A reduction in the number of waste bins needed. Analytics data to manage collection routes and the placement of bins more effectively.		10. YOUR SOLUTION You can put that reusable bottle to use, save money and reduce waste. By taking your own water with you, you'll also reduce your chances of purchasing more expensive beverages on-the-go. This will eliminate the one-time use containers they come in. While most cans and bottles can be recycled, they require a lot of energy to be produced, shipped to the bottling facility and then to the store for purchase.	Identify strong TR & EM
	4. EMOTIONS: BEFORE / AFTER Whenever the initiation of smart waste management system completed /started our environment will be neat and blank.				

Solution Architecture:

Solution architecture is a complex process – with many sub-processes – that bridges the gap between business problems and technology solutions. Its goals are to:

- > Find the best tech solution to solve existing business problems.
- > Describe the structure, characteristics, behavior, and other aspects of the software to project stakeholders.
- > Define features, development phases, and solution requirements.
- > Provide specifications according to which the solution is defined, managed, and delivered.

Solution Architecture Diagram



CHAPTER-4

Functional Requirements:

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story/ Sub-Task)
FR-1	Detailed bin inventory.	<p>The bins and stands which are monitored can be seen on the map, and we can also visit them at any time via the Street View feature from Google map. Bins or stands are visible on the map as green, orange circles.</p> <p>We can also see the bin details in the Dashboard – last weight measurement, GPS location and collection schedule.</p>
FR-2	Real time bin monitoring.	<p>The Dashboard displays which displays all the real-time data on filling levels of bins monitored by smart sensors. Along to the percentage of fill level, based on the previous data, the tool predicts when the bin will become full, one of the functionalities that are not included even in the best waste management software.. Sensors recognize picks as well; so you can check when the bin was collected last.</p> <p>With the help of real-time data and predictions, you can eliminate the overflowing bins and stop collecting half-empty ones.</p>
FR-3	Expensive bins.	<p>One can help you identify bins that drove up your collection costs. The tool calculates a rating for each bin in terms of collection costs.</p> <p>*The tool considers the average distance from depot to bin discharge in the area. The tool assigns bin a rating and calculates the distance from depot to bin discharge.</p>
FR-4	Adjust bin distribution.	<p>Ensure that the most optimal distribution of bins and identify areas with either dense or sparse bin distribution. Make sure that all trash types are represented within a stand.</p> <p>Based on the previous data, you can adjust bin capacity or location where ever necessary.</p>

FR-5	Eliminate Unefficient picks.	Removing the collection of half-empty bins. By using real- time data on fill-levels and pick recognition, we can showyou how full the bins can be collected.
FR-6	Plan waste collection routes.	The tool whichsemi-automates the wastecollection planning of route. Based on current bin fill levels andpredictions of reaching full capacity, we need to be readyto respond and schedule waste collection. We can also compare planned vs. executed routes toidentify any inconsistencies.

Non-functional Requirements:

Following are the non-functional requirements of the proposed solution.

FR No.	Non-Functional Requirement	Description
NFR-1	Usability	IoT device verifies that usability is a special and important perspective to analyze user requirements,which can further improve the design quality. In the design process with user experience as the core, theanalysis of users' product usability can indeed helpdesigners better understand users' potential needs in waste management, behavior and experience.
NFR-2	Security	Use a reusablebottles Use reusable grocery bags Purchase wiselyand recycle Avoid singleuse food and drinkcontainers.
NFR-3	Reliability	Smart waste management is also about creating better working conditions for waste collectors anddrivers. Instead of driving the same collection routesand servicing empty bins, waste collectors will spendtheir time more efficiently, taking care of bins thatneed servicing.

NFR-4	Performance	<p>The Smart Sensors use ultrasound technology to measure the fill levels (along with other data) in bins several times a day. Using a variety of IoT networks ((NB-IoT, GPRS), the sensors send the data to Sensoneo's Smart Waste Management Software System, a powerful cloud-based platform, for data-driven daily operations, available also as a waste management app.</p> <p>Customers are hence provided data-driven decision making, and optimization of waste collection routes, frequencies, and vehicle loads resulting in route reduction by at least 30%.</p>
NFR-5	Availability	<p>By developing & deploying resilient hardware and beautiful software we empower cities, businesses, and countries to manage waste smarter.</p>
NFR-6	Scalability	<p>Using smart waste bins reduce the number of bins inside town, cities coz we are able to monitor the garbage 24/7 more cost effective and scalability when we move to smarter.</p>

CHAPTER-5

5.1. DATA FLOW DIAGRAM:

A rapid rise in inhabitants across the globe has led to the inadmissible management of waste in various countries, giving rise to various health issues and environmental pollution. The waste- collecting trucks collect waste just once or twice in seven days. Due to improper waste collection practices, the waste in the dustbin is spread on the streets...



5.2 User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Admin (who manage web server)	Web server login	USN-1	As a admin, I have my user name and password for every worker and co-workers to manage them.	I can manage web account and direct workers.	High	Sprint-1
Co-admin	Login	USN-2	As a co-admin, I'll manage other monitoring activities like garbage level monitoring, location accuracy, garbage separation and removal of waste within a scheduled time.	I can monitor garbage bins activities.	High	Sprint-2
Customer (Web user)	User	USN-3	Here comes the customer, he/she will have access to mobile apps or login web pages to view progress of bins and to report if any query found.	He/ she has the right to make a query if any.	High	Sprint-3
Customer Care Executive	Worker	USN-4	The customer care executive, will try to rectify the queries from customers by contacting co-admin. If case of any critical/ emergency situation query can be conveyed to higher authority.	I can attend calls and respond people by rectifying the problem.	High	Sprint-4
Truck driver	Worker	USN-5	Here, truck driver is a worker who has particular assignments that he has to report when and where the garbage has been picked according to the daily schedule. And should update the happenings in the given website (web page login).	I can update my activities on site when the given task has been completed.	Moderate	Sprint-5

Sprint Planning

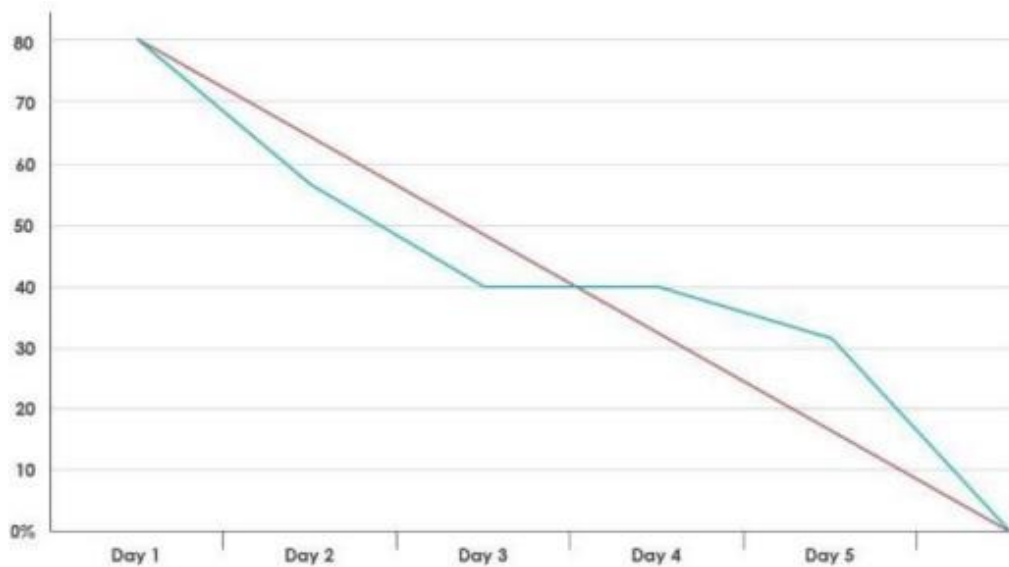
Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Login	USN-1	As a Co-Admin, I'll control the waste level by monitoring them via real time web portal. Once the filling happens, I'll notify trash truck with location of bin with bin ID	10	High	Selcia
Sprint-2	Dashboard	USN-2	As a Truck Driver, I'll follow Co-Admin's Instruction to reach the filling bin in short routes and save time	20	Low	Snehasri
Sprint-3	Dashboard	USN-3	As a Local Garbage Collector, I'll gather all the waste from the garbage, load it onto a garbage truck, and deliver it to Landfills	20	Medium	Muralitharan
Sprint-4	Dashboard	USN-4	As a Municipality officer, I'll make sure everything is proceeding as planned and without any problems	20	High	Vinotha

6.2 Sprint Delivery & Schedule:

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	05 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

Burn-Down Chart :

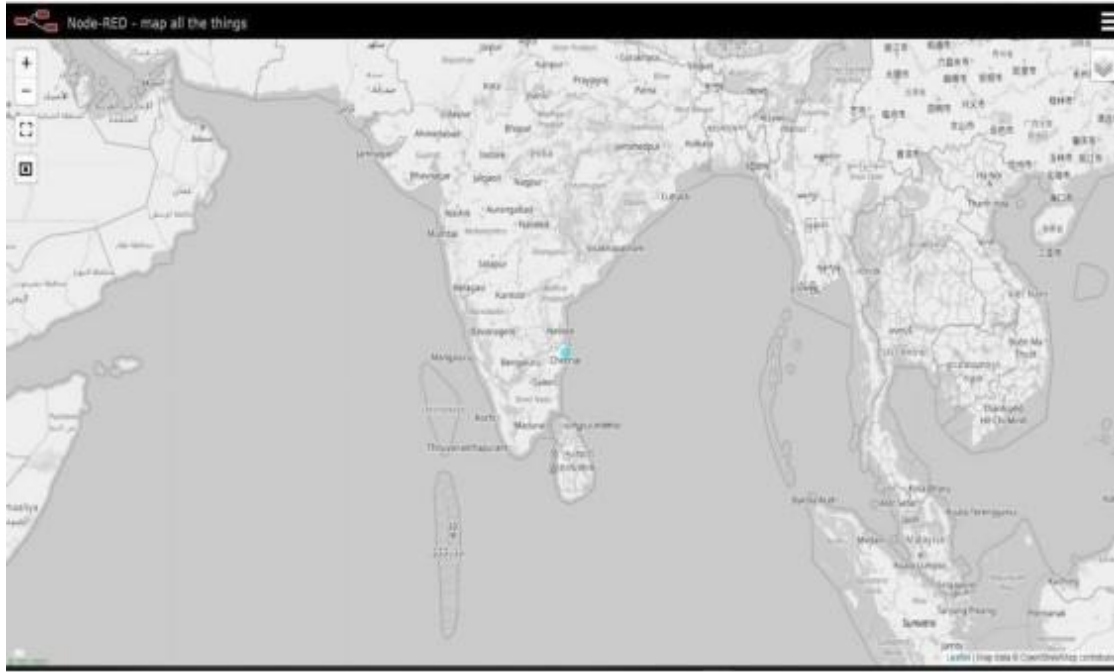
A burn down chart is a graphical representation of work left to do versus time. It is often used in agile software development methodologies such as Scrum. However, burn down charts can be applied to any project containing measurable progress over time.



CHAPTER-7

CODING & SOLUTIONING:

7.1 Feature 1- LOCATION TRACKER:



7.2. FEATURE 2- LIVE UPDATE ON COLLECTED DATA:

Smart Waste Management	
Monitoring layout	
BIN 1	
Location	Chennai - MMDA
Distance	12
Load cell	15
NEED BIN CHANGE !!!!	

CHAPTER-8

Testing

8.1. Testcases

TEST CASE ID	FEATURE TYPE	COMPONENT	TEST SCENARIO	PREREQUISITE	STEPS TO EXECUTE	TEST DATA	EXPECTED RESULT	ACTUAL RESULT	STATUS	COMMENTS	TC FOR AUTOMATION (Y/N)	BUG ID	EXECUTED BY
LOGIN PAGE_TC_001	FUNCTIONAL	HOME PAGE	VERIFY THE USER IS ABLE TO SEE THE LOGIN/SIGN UP WHEN CLICK ON MY ACCOUNT BUTTON		1. ENTER URL AND CLICK GO 2. VERIFY LOGIN UP	https://169.51.204.219.30106	LOGIN page is visible	Working as expected	PASS	Successful			SUDHESHWARIN

LOGIN PAGE_TC_003	FUNCTIONAL	LOGIN PAGE	VERIFY THE USER IS ABLE TO SEE THE LOGIN/SIGN UP WHEN USER CLICK ON MY ACCOUNT BUTTON		1. enter url and click go 2. click on my account 3. Enter valid ID 4. Enter valid password 5. click on login	Id:1111 password:5678	User should navigate your home page.	Working as expected	PASS	Successful			MUTHU KANNAN N
LOGIN	FUNCTIONAL	LOGIN	VERIFY		1. enter url	Id:1111	Confirm	Working	PASS	Successful			PRIYALAKSHMI M

PAGE_TC_004	L	PAGE	THE USER IS ABLE TO SEE THE LOGIN/SIGN UP WHEN USER CLICK ON MY ACCOUNT BUTTON		and click go 2.click on my account 3.Enter valid ID 4.Enter valid password 5.click on login button	password:5678	confirmation message sent	as expected		
LOGIN PAGE_TC_005	UI	LOGIN PAGE	VERIFY THE USER IS ABLE TO SEE THE LOGIN/SIGN UP WHEN USER CLICK ON MY ACCOUNT BUTTON		1.enter url and click go 2.click on my account 3.Enter valid ID 4.Enter valid Password 5.click on login Button	Id:111 password:5678	Confirmation message sent	Working as expected	PASS	

LOGIN PAGE_TC_006	FUNCTIONAL	LOGIN PAGE FOR ADMIN	VERIFY THE USER IS ABLE TO SEE THE LOGIN/SIGN UP WHEN USER CLICK ON MY ACCOUNT BUTTON		1.enter url and click go 2.click on my account 3.Enter valid ID 4.Enter valid password 5.click on login button	Id:111 password:5678	Custom database is visible	Working as expected	PASS	AKSHAR ASS
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8.2 User acceptance Testing:

1. Purpose of Document The purpose of this document is to briefly explain the test coverage and open issues of the [ProductName] project at the time of the release to User Acceptance Testing (UAT).
2. Defect Analysis This report shows the number of resolved or closed bugs at each severity level, and how they were resolved

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	10	4	2	3	20
Duplicate	1	0	3	0	4
External	2	3	0	1	6
Fixed	11	2	4	20	37
Not Reproduced	0	0	1	0	1
Skipped	0	0	1	1	2
Won't Fix	0	5	2	1	8
Totals	24	14	13	26	7

CHAPTER-9

RESULTS



9.1. Performance Metrics:



10. ADVANTAGES & DISADVANTAGES ADVANTAGES:

- Reduction in Collection Cost
- No Missed Pickup
- Reduced Overflow Waste Generation Analysis
- CO2 Emission Reduction

DISADVANTAGES:

- System requires a greater number of waste bins for separate waste collection as per population in the city.
- This results into high initial cost due to expensive smart dustbins compare to other methods. Sensor nodes used in the dustbins have limited memory size.

11. CONCLUSION:

A Smart Waste Management system that is more effective than the one in use now is achievable by using sensors to monitor the filling of bins. Our conception of a "smart waste management system" focuses on monitoring waste management, offering intelligent technology for waste systems, eliminating human intervention, minimizing human time and effort, and producing a healthy and trash-free environment. The suggested approach can be implemented in smart cities where residents have busy schedules that provide little time for garbage management. If desired, the bins might be put into place in a metropolis where a sizable container would be able to hold enough solid trash for a single unit. The price might be high.

12. FUTURE SCOPE:

There are several future works and improvements for the proposed system, including the following:

1. Change the system of user authentication and atomic lock of bins, which would aid in protecting the bin from damage or theft.
2. The concept of green points would encourage the involvement of residents or end users, making the idea successful and aiding in the achievement of collaborative waste management efforts, thus fulfilling the idea of Swachh Bharath.
3. Having case study or data analytics on the type and times waste is collected on different days or seasons, making bin filling predictable and removing the reliance on electronic components, and fixing the coordinates.
4. Improving the Server's and Android's graphical interface